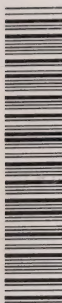


# the gifts of nature



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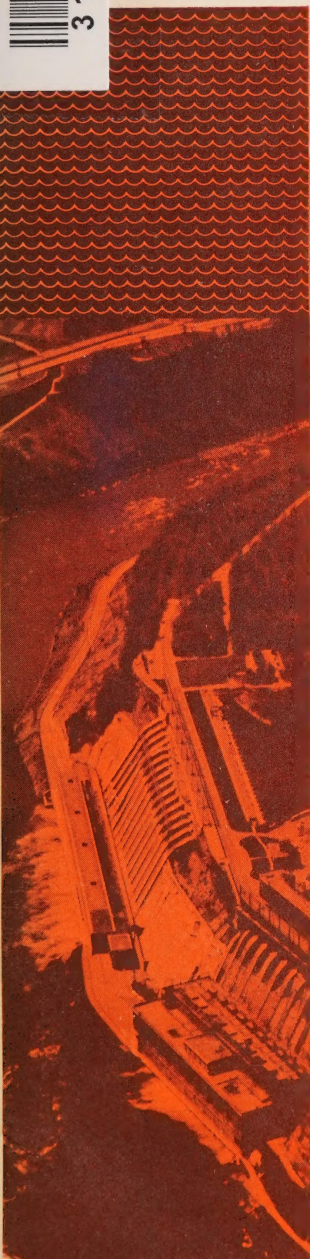


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# the gifts of nature

*Electricity is the life-blood of modern society.  
Supplying the ever-growing demand for this vital form of  
energy in Ontario is a constant challenge.  
This booklet tells the Hydro story.*

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*Published by  
The Hydro-Electric Power Commission of Ontario  
(Ontario Hydro)  
1st printing 1961 • revised 1965, 1968, 1970.*



# foreword

This booklet is designed to help you learn more about Hydro in Ontario. It tells about the birth of the public power enterprise in the early years of the century, the steady and sometimes rapid expansion of Hydro and its plans for the future.

Today Ontario is the foremost industrial and agricultural province in Canada. Its industries account for about 50 per cent of Canada's total manufacturing output and approximately one-third of all Canadians reside in Ontario. At the same time, the income of Ontario people is well above the Canadian average. An ample supply of low-cost electricity has been an important factor in economic expansion and high standards of living.

The Latin motto of Ontario Hydro is "Dona Naturae Pro Populo Sunt", which means "the gifts of nature are for the people". For more than 60 years dedicated people, both in Ontario Hydro and some 350 associated municipal utilities, have ensured that nature's gifts — waterpower, coal, uranium and electricity itself — are harnessed to provide an abundant supply of low-cost power for the province, when and where it's needed.

Each day a new chapter in the Hydro story is being written: on a new dam spanning a turbulent river....on a coal-fired plant supplied by a procession of Great Lakes freighters....on a nuclear power station rising on the outskirts of Metro Toronto....at a central control room monitoring the flow of power from generating stations to customers around the province....by municipal utility linemen repairing damage from a

wind-felled tree. Each day thousands of Hydro staff members work to ensure continuous electrical service for some 2.3 million customers around the clock.

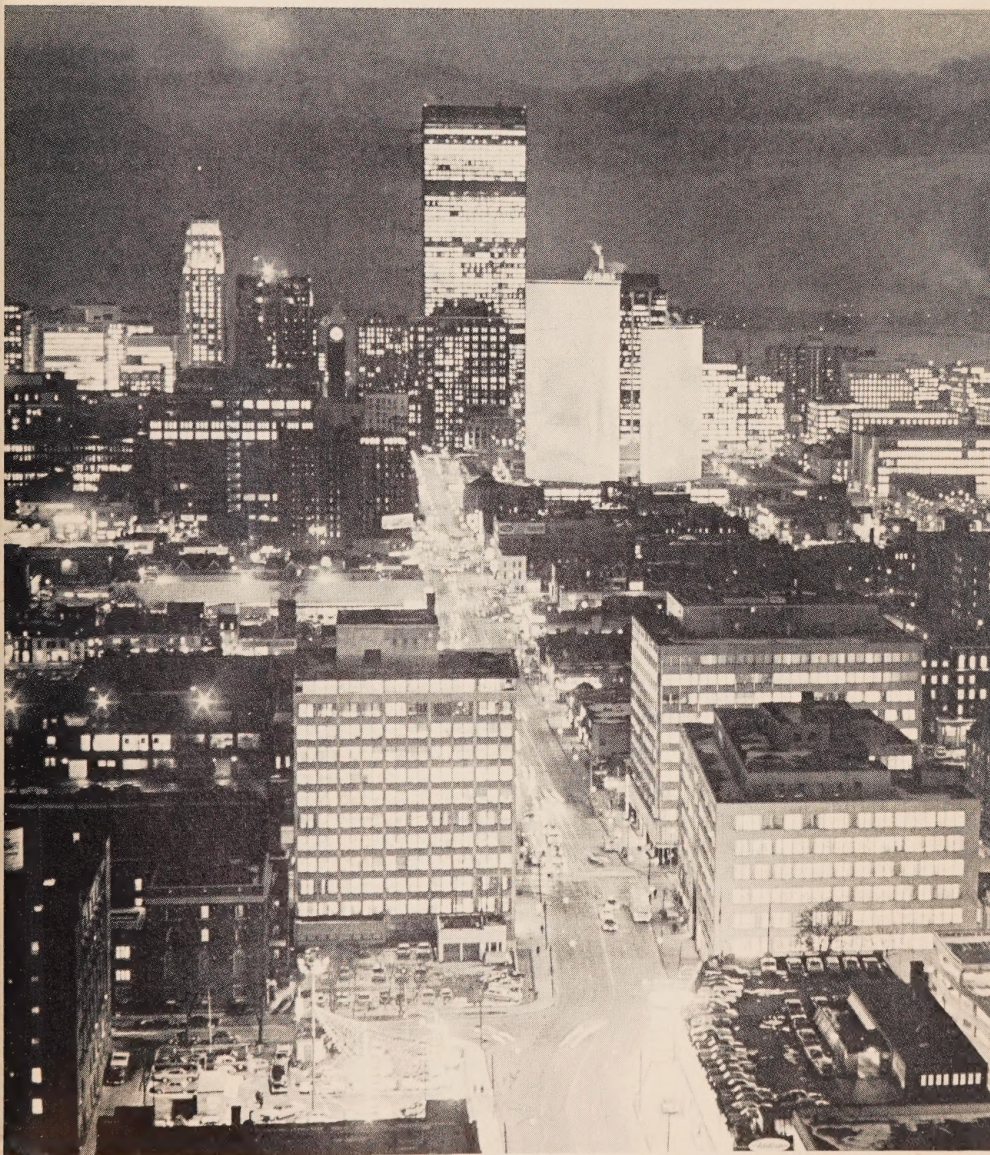
In the era of the computer, extra-high-voltage transmission and nuclear energy, the co-operative Hydro enterprise uses many skills and talents in striving to maintain high standards of public service.

*More than 570,000 rural customers are served directly by Ontario Hydro.*





*Municipal Hydro systems supplied by Ontario Hydro  
serve more than 1.7 million urban customers.*



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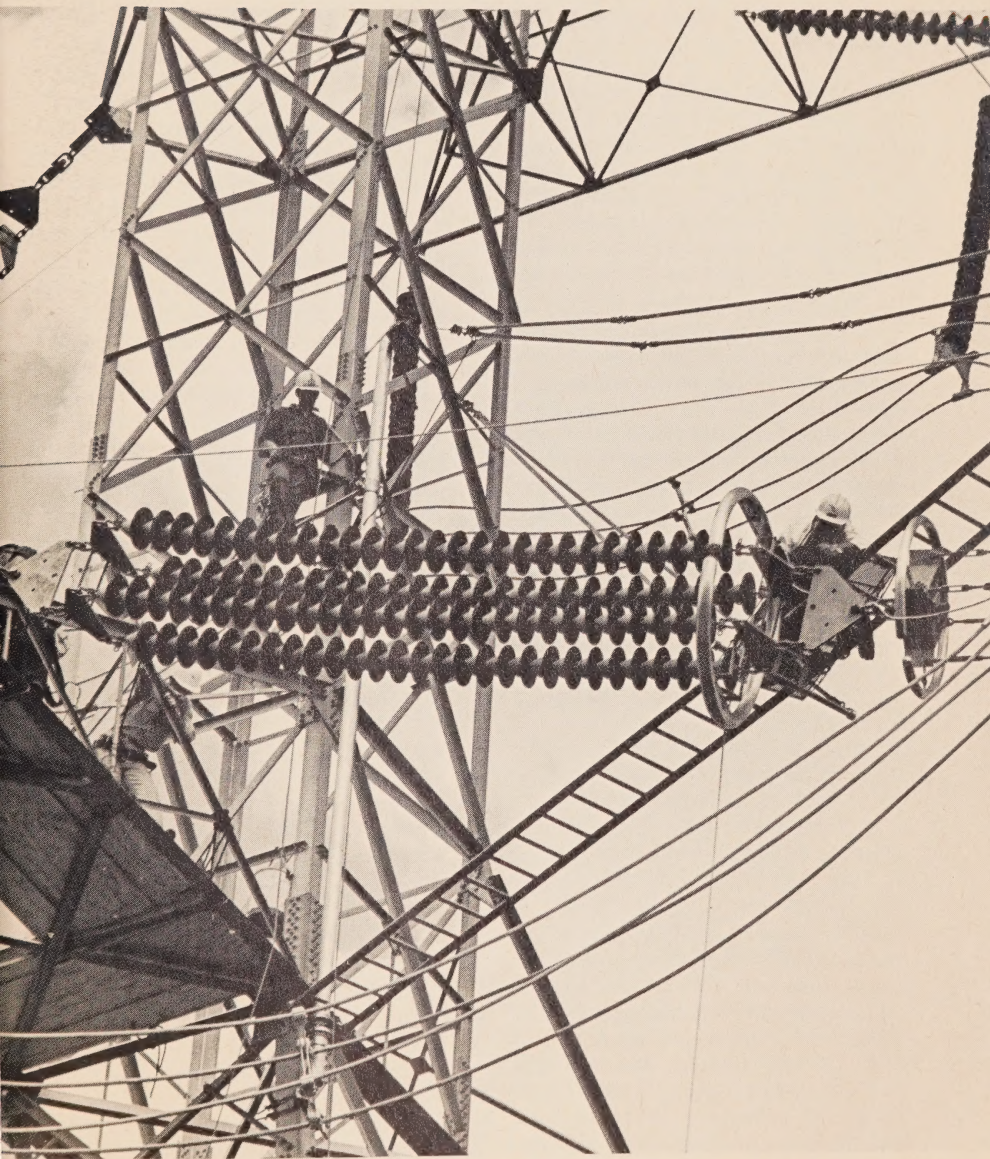
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# the electricity story

*Hydro has pioneered in high voltage transmission techniques.*



## dance of the electrons

Switch on your reading lamp and something magical happens. Energy instantly flows from a distant waterfall, a blazing coal fire or a disintegrating pellet of uranium. It's produced by machines which place at man's fingertips the might of falling water, the force of steam and the power of the atom.

The electric current flows along power lines to your home, sometimes across hundreds of miles, at the speed of light. If an airplane travelled at the same speed it could circle the earth at the equator roughly seven-and-a-half times in one second. Yet we accept the fact that our lamp lights up with hardly a thought.

Actually man's quest to understand and use electricity began 2,000 years ago in ancient Greece. The history books tell about the discoveries in the 18th and 19th centuries of such electrical pioneers as Luigi Galvani, Alessandro Volta, Hans Christian Oersted, Michael Faraday, Thomas Edison and Nikola Tesla which added to man's store of knowledge. But it's only in the past 90 years that rapid progress has been made in using the invisible current of electricity as a source of energy.

What happens in the thin copper wire that leads from your lamp to the electrical outlet? Billions of electrons—tiny particles carrying a negative charge of electricity—move along the wire. Jostling together, the electrons all try to flow at the same time through the hair-thin filament in the light bulb. As they meet resistance the electrons

give off both heat and light.

Next time you turn on your lamp remember this furious dance of the electrons which occurs in all electrical circuits. Electrons can't be seen but scientists have calculated their minute weight and size. Billions and billions of them—gifts of nature unlocked by human ingenuity—flow through power lines to provide light, heat and energy to do man's work, and provide for his comfort and enjoyment.

## magnetism

Most electrical machines and instruments depend on magnetism and it is important that you should know something about magnets if you are to understand how electricity is produced. Magnets are of two types, natural and artificial. Natural magnets, used more than 2,000 years ago, are found in a particular type of iron ore called lodestone. This lodestone has the power of attracting iron.

As the earth is a huge magnet, a lump of lodestone will always swing into a north-south direction if suspended on a piece of string, because it is attracted by the north and south poles. The original compasses used in ships many years ago were based on this principle and were probably little more than suspended lodestones.

These natural magnets not only point to the north when freely suspended but the same end of each magnet always points to the north. The other end of the magnet always swings away from the north. So the north-pointing end of a magnet is called the "north

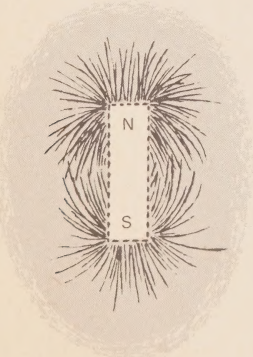


pole" and the other end is called the "south pole".

With two or more magnets, it was found that the north pole on one would attract the south pole on another whereas the north pole on one would push away the north pole on another. These facts about magnetic force are summarized by saying that like poles repel and unlike poles attract.

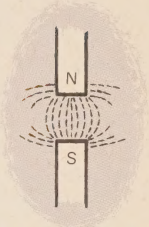
While this force radiated by magnets cannot be seen, through a simple experiment the area or field in which the force operates can be detected. Put a bar magnet under a piece of paper and sprinkle some iron filings on the paper. The iron filings will be moved by the magnetic force passing through the paper and will arrange themselves into curved lines. (It may be necessary to tap the paper gently to assist the iron filings to move into position).

A similar experiment may be carried out with two magnets to see the magnetic field existing between them. The curved lines indicated by the iron filings are called "lines of force".

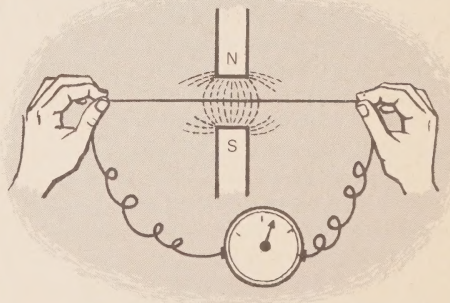


## induced current

In these iron filings experiments, you can see that lines of force will exist between the north pole of one magnet and the south pole of another, provided they are not too far apart.



Such lines of force form a "magnetic field", which is a basic requirement for the production of electricity. If a loop of wire is moved rapidly through this magnetic field, a tiny electric current will be produced in the wire. This is called an "induced current" and it is produced because the wire "cuts" the lines of force between the two magnets as it passes through the field. The current produced in the wire is greatest when the wire is moved at right angles to the lines of force.



With a very sensitive instrument for measuring electricity called a galvanometer, you can detect electricity produced in this way. Connect a loop of wire to a galvanometer and then move the loop

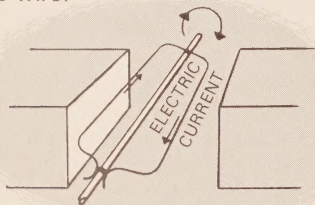
quickly through the magnetic field between two magnets. The galvanometer needle will give a little "kick" showing that some electricity passed through it.

Generators, the machines which produce electricity, are based on these simple facts. To help you understand how a generator is made, a simple one will be described. Of course, this simple generator would not produce much electricity, but it will show the way that the big ones work in Ontario Hydro's generating stations.

## building a simple generator

An electric current, as we have seen, is induced in a wire if the wire is moved quickly through the field between two magnets. To keep producing electricity, therefore, the wire must be kept moving through the magnetic field so that it is continually cutting the lines of force. The best way to do this is to fasten a loop of wire on a shaft and to spin the loop around between the two magnets.

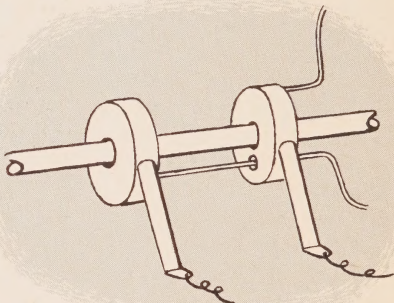
As long as the loop of wire is spinning, each side of the loop is cutting the lines of force and electric currents are thereby being produced in the wire.



Now there is a problem. Electricity is being produced in the spinning loop of wire but it is no use to you unless you can get it out.

You cannot join wires to the ends of the loop, because everything would become hopelessly entangled as soon as you started spinning the loop. So it is necessary to make a special "pick-up" whereby the electric current produced in the spinning loop may be picked up and passed to outside wires which will conduct it to wherever it is needed.

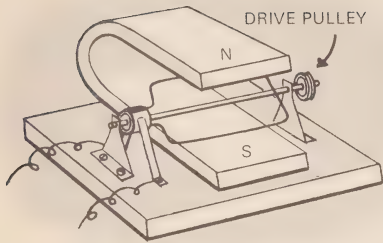
This pick-up is called a "collector ring" and it is built on the generator shaft.



The drawing above shows the simplest type of pick-up. Each end of the wire loop is connected to a separate metal ring mounted on the shaft. As the shaft spins, the electricity produced in the loop of wire will flow into the metal rings. It may be picked up from there by having "brushes" pressing against the rings as they turn.

The sides of the rotating coil are passing in front of a north pole and a south pole alternately, and thus the direction of the induced current reverses each time a pole is passed.





This results in an "alternating current". One positive pulse and one negative pulse of current constitute one "cycle", and the number of such cycles of current in one second is called the "frequency". The frequency of power supply to most customers in Ontario is 60 cycles per second, or just "60 cycles".

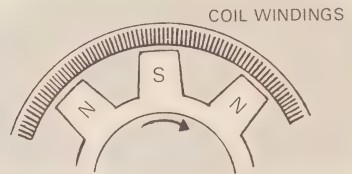
## large generators

Such a generator, however, could only produce a minute electric current—not even enough to light a small bulb!

Instead of one loop of wire on the shaft, many loops must be used so that all the tiny currents induced in each loop can be added together at the collector rings and combined into one big current. These induced currents are increased still more by winding the loops of wire around iron plates mounted on the shaft.

In large generators, many magnets are used and are mounted all the way around the machine in a circle. By doing this, the loops of wire on the shaft "cut" many more lines of force as they spin around, and thus more electricity is produced.

Huge generators, like those used by Ontario Hydro, are even built "inside out". The magnets spin around on the generator shaft in the centre of the machine, while all the loops of wire or coils are built in a circle outside the generator shaft. So the coils of wire stay still while the magnets are spinning.



While much more might be said about large generators, the details are complicated. But no matter how large and complex the generators may be, you will always find one simple idea at the back of them all: Somehow or other, coils of wire are made to "cut" through magnetic fields, thus producing electric current.

## driving the generator

You have seen how a simple generator may be made and also some of the ways in which large generators produce large quantities of electricity. In each case, large generator or small one, the generator shaft has to be spun around and around before electricity is produced.

With small generators, you could turn the shaft around by hand, or hook it up to a bicycle, and then pedal it. The electricity produced would light a

bulb but as you became tired, slowed down and finally stopped, the electric light would first go dim and then go out.

With extra large generators, a tremendous force is required to spin the shaft and generate electricity. So a motor of some kind must be used to spin the shaft around.

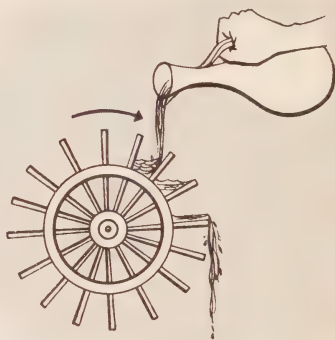
A steam engine would be suitable—similar to those in the old locomotives—or a diesel engine, which the new locomotives and big trucks now use. You could also use a gasoline engine such as you have in automobiles. Steam engines use coal, natural gas, oil, or heat from nuclear fission; diesel engines use oil; while gasoline engines use gasoline. The cheapest engine to operate, however, is the water turbine because the only driving force it requires is falling water.

## water turbines

If you make a paddle wheel and put it on an axle, you can spin the wheel by hitting the paddles with your fingers. You can also make it spin by dropping water on the paddles. Hold a jug full of water above the wheel and pour the water on the paddles. The falling water hits the blades and pushes the wheel around. You can see that if you hold the jug higher and pour the water more quickly, the wheel will turn faster. So if you made a paddle wheel large enough and then held a whole river up high and poured it on the paddles, you would have a very powerful driving

force; in fact, something very similar to the way a water turbine operates.

At most suitable sites throughout the province, Ontario Hydro has built, or is building, dams across rivers. These dams back up the water and raise the water level of the river. Then a pipe, called a "penstock", is put in the dam so that the water, held back by the dam, can drop downward.



This water rushes down the penstock with great force and hits the turbine runner ("paddle wheel") at the bottom. The runner starts spinning when the water hits it, and when the energy of the falling water has served its purpose, the water runs out through the tailrace of the generating station to join the main stream of the river.

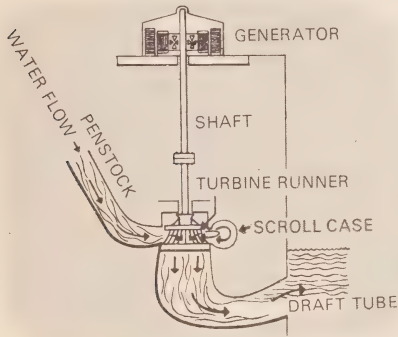
## turbo-generators

All that remains to be done is to connect the turbine shaft with the generator shaft and then open up the water supply. The turbine runner is



set spinning by the falling water and this spins the generator shaft. As soon as the generator shaft starts turning, electricity is generated.

When a turbine of any kind is used to drive a generator, the combined machine is called a "turbo-generator". Usually the shaft is very big and strong and has the generator built on one end of it while the turbine is connected on the other end.

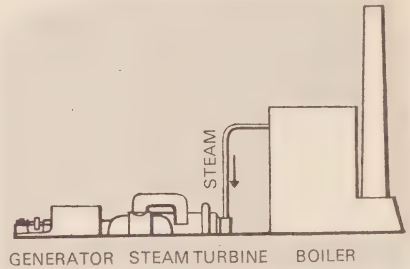


In this way, most of the electricity used in Ontario is still produced by water power, and the method is called hydro-electric generation. Electricity is produced by the generator, and the force of the falling water is used to turn the turbine and generator shaft.

## steam turbines

Our province is growing every day. The population is increasing, new homes and new factories are being built. All this means that Ontario needs more and more electricity. Unfortunately very few suitable places

are left where we can build dams across rivers and make the river water turn our generators. So Ontario Hydro uses steam power as well as water power to turn the generators.

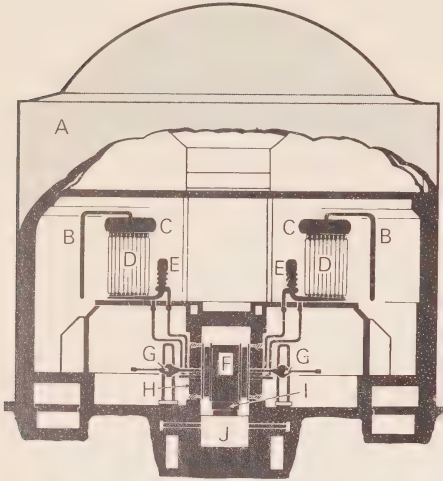


Generators driven by steam turbines are known as steam turbo-generators, and plants in which they are installed are called thermal-electric generating stations. Thermal means heat. In Ontario Hydro's thermal stations heat to convert water into steam, which drives the turbines, is created by burning coal or splitting uranium atoms—nuclear fission. In a nuclear station the reactor performs the function of the furnace in a coal-fired station.

The Douglas Point nuclear station uses natural uranium which contains two kinds of atoms—uranium-235 and uranium-238. Usually only the uranium-235 atoms split or "fission" in a nuclear reactor.

The heart of each uranium-235 atom consists of neutrons and protons. When struck by a slow neutron a uranium-235 atom splits into two pieces which fly apart with great energy. As these two pieces move through the uranium fuel—and they move only a few thousandths of an inch—they collide with other atoms

## NUCLEAR GENERATING STATION



- |                             |                           |
|-----------------------------|---------------------------|
| A - reactor building        | F - reactor               |
| B - steam pipes to turbines | G - fuelling machines     |
| C - steam drums             | H - end shield            |
| D - heat exchangers         | I - dump port             |
| E - heavy water pumps       | J - heavy water dump tank |

In some ways the steam turbine is like the water turbine; but instead of having falling water hit the blades of the turbine runner, jets of 1,000-degree high-pressure steam provide the force necessary to turn the turbine.

The shape of the "runner" is quite different, and the big, heavy blades used in a water turbine become small, sharp blades in a steam turbine. But the idea is much the same. The steam hits the turbine blades and sets the turbine spinning. Once again, all you have to do is to connect the generator to the steam turbine and electricity will be produced.

To sum up, it's necessary to turn the generator shaft to produce the electric current. It does not make any difference what is used to drive the generator. It may be a water turbine, a turbine driven by steam made by nuclear power, or any other kind of driving force. The choice depends on many things, one of the most important being its cost.

## transmission

Next comes the delivery of power produced by generating stations to our homes, stores, offices, farms and factories where it will be used.

Today the word "volt" is familiar to nearly everyone. It is a unit of measurement and means the pressure

causing the uranium to become hot.

Two or three fast neutrons, travelling at an average speed of 12,000 miles a second, are emitted when a uranium-235 atom splits. These fast neutrons must be slowed down to one or two miles a second before they will split other uranium-235 atoms.

Fast neutrons travel through heavy water where they bounce against heavy hydrogen atoms. These collisions reduce or "moderate" the speed of the neutrons. The slow neutrons then split other uranium-235 atoms, producing still more neutrons. Thus there is a continuous splitting of atoms—a "chain reaction"—and a steady generation of heat.

Several other fuels, including oil and natural gas, may also be used to create steam in thermal-electric stations. In some countries generating stations use natural steam from underground volcanic sources.



of an electric current. In other words, it is the "push" behind the current.

We use different voltages or electric pressures on various occasions.

Modern large generators are usually made to produce electricity at 13,800 volts.

Now, in most cases, electricity has to be sent along transmission lines for long distances—possibly hundreds of miles—and this can best be done if the electric current is at a very high voltage.

Whenever electricity is sent along a wire, some of it is lost so that you get less out of the end of the wire than you put in at the beginning. The longer the wire, the greater is the loss; and the higher the voltage, the less the loss over a constant distance.

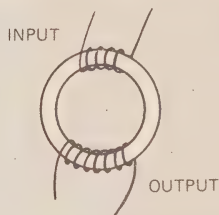
A large part of this loss occurs because the electric current encounters resistance in passing through the wire. Electric energy is given off in the form of heat.

These losses are much smaller if the voltage is increased. So as soon as the electric current leaves the generator, it is passed immediately to a special device called a transformer which can raise or lower the voltage. At the generating station, these transformers are called "step-up" transformers, since they are used to step up (or increase) the voltage.

## transformers

Large transformers are complicated pieces of equipment but, like so many other devices, they are based on a simple idea.

If a wire carrying an electric current is wrapped several times around a bar of iron it will induce magnetic lines of force in the iron. If the iron bar is made as a ring, the magnetic lines of force will flow around the ring. Now if you wrap several turns of another wire around the ring, you will find an electric current is induced in this second wire whenever the current in the first wire changes or reverses its direction.



In other words, a wire carrying alternating electric current can transfer this current to another wire, without any direct connection between the two wires, by using the magnetic properties of iron. The voltage of the induced current depends upon the number of turns of wire wrapped around the ring, the voltage increasing as the number of turns of wire increases.

A transformer has two sides, input and output. The input side is connected to the source of power; in this case, the generator. The output side is connected to circuits requiring the power; in this case, the transmission lines. By placing more turns of wire on the output side of the transformer than on the input side, the voltage

can be increased to the high level required for long distance transmission. The transformer does not affect the amount of electric energy, but only the pressure. Apart from some minor losses during the changeover in the transformer, the amount of electric energy is unaltered.

## transmission and transformation

When electricity leaves the generating station it starts the journey to where it will be used. As long distance transmission is most economical when the electricity is carried at high voltage, the electricity from the generators is passed through the transformers to step up the voltage.

For carrying power up to 300 miles, Ontario Hydro normally uses pressure of either 115,000 or 230,000 volts. To bring power economically from remote sites in the north to the more populous centres of the south, however, requires much higher voltages than have previously been used, and for this purpose Hydro has built a transmission line which uses 500,000 volts.

Electrical engineers use a short way of writing high voltages. They use the term "kilovolts" or kv for short. A kilovolt is simply 1,000 volts. So in Ontario Hydro, engineers speak of high voltage lines as 115 kv, 230 kv or 500 kv.

Power lines from the generating stations are spread like a net over the province and are joined together at the main transformer stations in

different areas. The network is usually called a "grid system" and power coming into the grid from any source may be used to supply any part of the area the grid covers.

One grid system may be interconnected with other grid systems so that one utility may help the other at any time one of them suffers a power shortage or interruption. For instance, Ontario Hydro's East System, covering Southern and Northeastern Ontario, is interconnected with part of Quebec and the states of New York and Michigan. These grids are part of a vast power pool which covers more than half of the North American continent—from the James Bay watershed to the Gulf of Mexico, west to the Rocky Mountains and east to the Atlantic Ocean.

This power pool operates in electrical synchronization with interconnected utility systems in British Columbia and along the Pacific coast of the United States.

Ontario Hydro's West System, which serves Northwestern Ontario, is linked with Manitoba and Saskatchewan. In 1970 it was fully interconnected with the East System to form an electrical network serving the entire province. Bridging the gap was a major step in the development of a national power grid in Canada.

From main transformer stations in Ontario, lower voltage lines conduct the power to cities and factories. As such journeys are usually short, lower voltage is used. It is "stepped-down" to 27.6 kv by transformers which work in reverse to the "step-up" transformers.



## distribution



As a voltage of 27.6 kv used for shorter distances is not suitable or necessary for distribution throughout a municipality or rural district, it is usually further stepped down to 4,000 volts. Some big machines use the power at 4,000 volts, but most electric motors, as well as the appliances we use at home and at

school, need the power at lower voltage. So it is stepped down once more, usually from 4,000 volts to either 120 or 240 volts. The transformers that do this are quite small and are usually located on street poles. There is probably one of these outside your school or on the street where you live.

## behind the switch

Behind the switch thousands of people with many skills work to ensure continuity of service. Some are involved in day-to-day operations. Many are taking training to cope with the growth of new technology. Others are planning or building facilities to serve Ontario in the future.

Ontario's power needs double every 10 to 12 years. In the next decade Hydro must build new stations to generate more power than is now produced by all the stations built over the last half century or so.

Over the years Hydro has been fortunate in obtaining staff members dedicated to service. Some of the people who work unseen and unheralded behind the switch are:

- Engineers and draftsmen designing new stations.

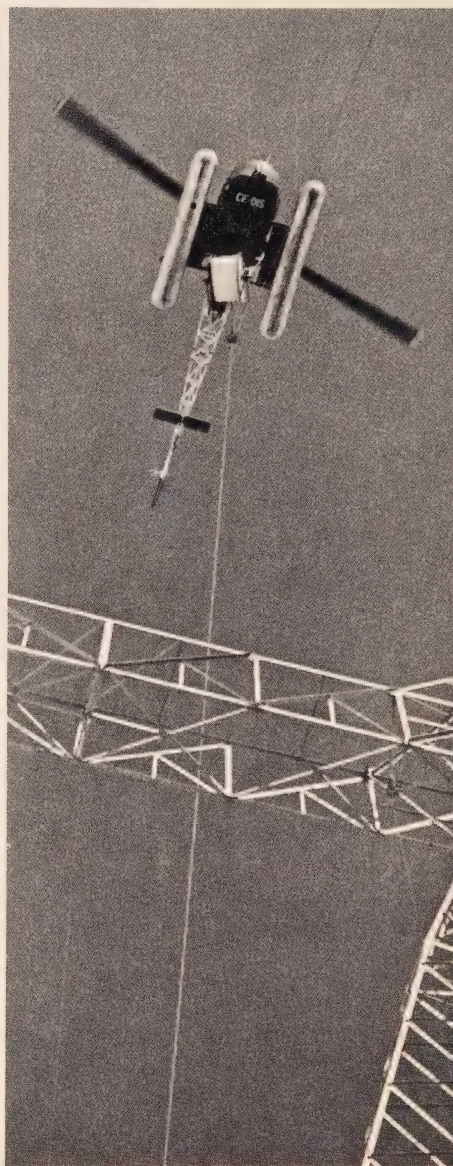


- Construction forces building new stations and erecting new power lines.
- Operators in remote generating stations and power supervisors in a central control room sending electricity where it's needed.

- Linemen and foresters working to prevent power interruptions and to restore service after storms.
- Helicopter pilots and observers patrolling a lonely parade of towers along transmission lines.
- Technicians testing complex electronic equipment used to control modern generating and transmission stations.
- Communications experts keeping microwave radio and high-speed teleprinters in working order.
- Research workers testing equipment and products used by Hydro, solving problems and looking for better ideas.
- Chemists, physicists and meteorologists employing their special talents to avert air and water pollution.
- Computer programmers feeding data to electronic data processing machines to help Hydro improve efficiency and security of service.

Many others, such as power maintenance electricians, pipe fitters, surveyors, cartographers, geologists, safety officers, librarians, stenographers, statisticians and skin divers, play a vital but silent role in serving Ontario with electricity. But the story does not end with Ontario Hydro. More than 350 municipal electrical utilities, composed of staffs with a wide range of skills, serve our cities, towns and villages. The municipal commissions are responsible for distributing power to homes, stores and factories.

*Hydro was among the first in the utility field to make extensive use of helicopters.*





*Hydro folk run the gamut from chemists to draftsmen and from technicians to linemen.*



Customers in rural areas are served directly by Ontario Hydro through more than 60 Area Offices.

To keep pace with the rapid growth in technology and the need for new skills, many Hydro employees take training to prepare for the future. Courses are held regularly for such groups as junior engineers, nuclear plant operators, computer programmers, linemen, foresters and other tradesmen. Others improve their qualifications by taking courses at night schools, technological institutes and universities.

In 1965 Ontario Hydro and many of the associated electric utilities adopted the bright orange and vermillion O-H symbol which has now become familiar across Ontario. Next time you see this proud symbol—or flick a switch to watch TV—remember the many people who work, sometimes around the clock, to keep electricity flowing in the power arteries of the province.



# power for the people

*Cofferdam construction on the Niagara in pre-Hydro days.  
These plants were later acquired by Ontario Hydro.*



## building the system

During the 1890s, power was provided to some of the larger cities in Ontario by small thermal-electric plants, mainly privately-owned.

In 1895 the waters of the Niagara River were harnessed for electric power at Niagara Falls, N.Y. This was the first major hydro-electric station ever to be built and it introduced a new pattern for electric power to North America. It was particularly meaningful for Ontario as the province was lacking in coal resources for thermal-electric generation but rich in water resources.

In the following two decades, numerous water power leases were let to various private companies in Ontario. The hydro-electric plants built—far, far less than the number of leases—were almost all small stations serving local areas.

The Toronto Board of Trade, in 1900, appointed a committee to examine the question of electric power supply generally. The committee reported that the Niagara River, in its opinion, was the most economical source of power for Toronto. The committee also raised the question whether or not the City of Toronto should own and operate the necessary transmission lines from Niagara.

The major portion of Ontario's early hydro-electric power development was in the Niagara Falls area. For example, in 1898 the Cataract Power Company brought into operation the DeCew Falls Generating Station, which took its water supply from the nearby Welland Canal; the Canadian Niagara

plant began operating in 1904; the Ontario Power Generating Station, in 1905, and the Toronto Power Generating Station, in 1906, all on the Niagara River.

With the exception of the DeCew plant, all these stations delivered power at 25 cycles. This frequency was chosen because it had already been adopted by part of New York State and the companies responsible for developments on the Niagara River viewed this area across the border as the immediate market for electric energy.

Meanwhile public sentiment was being aroused on the need for low-cost power. Representatives of different cities, boards of trade and manufacturers' associations were holding meetings.

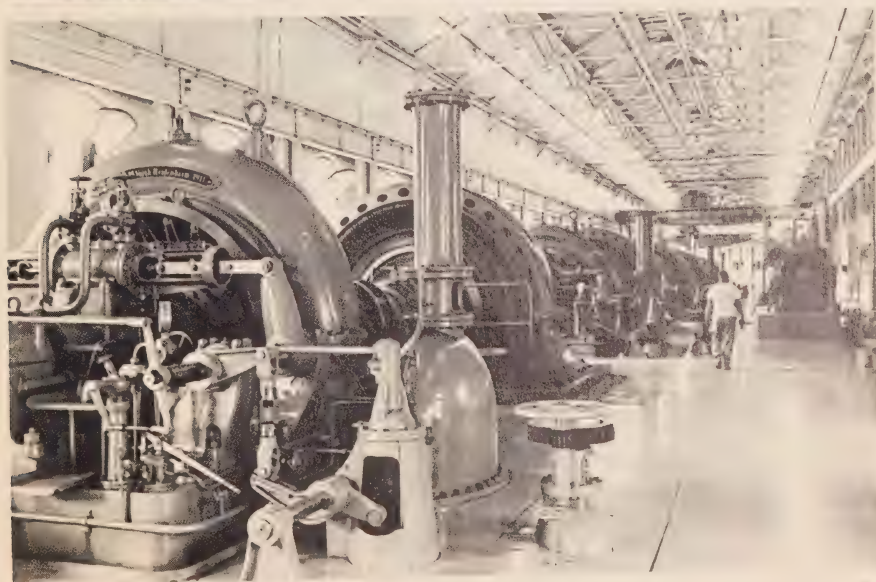
In 1903 a meeting took place in Berlin (now Kitchener), Ontario. Among the persons attending were E.W.B. Snider and Daniel B. Detweiler, who were leading advocates of publicly-owned power, and Adam Beck, then Mayor of London. From this time forward, Sir Adam (as he later became) assumed a position of leadership in the movement for low-cost power.

A committee of the Provincial Legislature reported on the subject, and in 1906 an Act was passed, which provided for the formation of The Hydro-Electric Power Commission of Ontario and dealt with the supply of electric power to the municipalities. The Act received Royal Assent on May 14; and on June 7, 1906, the first Commission came into being with Adam Beck as Chairman.

In 1907 the Act was repealed and



*Steam-operated drills at work on Chippawa power canal at Niagara in 1921.  
Interior of DeCew Falls plant, oldest in the Hydro system,  
is shown below. It was built in 1898, near St. Catharines.*



*This photo shows Waterloo Public Utilities Commission "squirrel gang" building local system in 1912.*

re-enacted under the name of "The Power Commission Act". Under this Act, as amended, Ontario Hydro continues to operate as a corporate body administering a province-wide enterprise for the production and distribution of electric power at cost.

In the beginning, the Commission was purely a distributing agency for power purchased on behalf of the municipalities. The initial plan was to obtain a block of 100,000 horsepower (75,000 kilowatts) from the Ontario Power Company at Niagara Falls and to distribute this power to the municipalities which had signed contracts with the Commission.

Construction of a transmission system to distribute power to the contracting municipalities was begun in 1909. By the end of the following year, power was being supplied to eight of these municipalities. By this time, too, the Ottawa and Hull Power and Manufacturing Company had signed a contract with Ontario Hydro to provide power to the City of Ottawa.

By 1910 the Commission had built a four-mile transmission line and a substation to service Port Arthur with power purchased from the Kaministiquia Power Company.

The two pioneer systems—the Niagara area in the south and the Port Arthur district in the north—eventually grew into the Southern Ontario and the Thunder Bay systems.

During early development, private enterprise continued to develop hydro-electric resources in various parts of the province. Coniston Generating Station on the Wanapitei River was in operation in 1905; Big



Chute on the Severn began initial service in 1909; Seymour on the Trent and Auburn Generating Station on the Otonabee were all in operation by the end of 1911.

Ontario Hydro later acquired all these plants in the course of extending electrical service to the municipalities across the province. As the Commission's financial strength grew, it was able to undertake minor developments of its own as well as acquire plants in deals with private companies.

Big Chute, in 1914, was the first generating station to be bought. Later the same year, the first generating station which the Commission itself built was placed in service. This was at Wasdell Falls on the Severn River. In 1917, the Commission purchased the Ontario Power Company plant at Niagara Falls, the source of its original power. This was followed in 1922 by the acquisition of the Toronto Power Company's plant at Niagara.

The program of purchase and construction of plants thus inaugurated reached its first climax with the building of the Queenston-Chippawa development to utilize power from the Niagara River. Now known as Sir Adam Beck-Niagara Generating Station No. 1, this plant first delivered power early in 1922. Sir Adam Beck-Niagara Generating Station No. 2, more than three times larger than the first, was built after World War II.

By the end of 1922, the Commission's resources totalled 496,000 kilowatts to meet demands of 460,700 kilowatts. In Hydro's first year of active operation (1910) demands were only 4,000 kilowatts.

In 1944, the Southern Ontario System was created through consolidation of the Niagara, Georgian Bay and the Eastern Ontario systems. The new system served the older and more populous part of Ontario, lying south of a line drawn from Mattawa on the upper part of the Ottawa River approximately west to Georgian Bay.

In the north, during the 1930's the Commission had undertaken to operate, in trust for the Provincial Government, a group of unconnected systems

serving mainly mining and pulp and paper industries. This grouping became known as the Northern Ontario Properties.

In 1944, Commission services in the north were further extended by purchase of the power system of the Northern Ontario Power Company Limited. In 1952, the Northern Ontario Properties and the Thunder Bay System were merged for financial and administrative purposes and the consolidation continued to be known as the Northern Ontario Properties.

Finally, in 1962, the Southern Ontario System and the Northern Ontario Properties were amalgamated. For financial and administrative purposes, there is now only one system.

For electrical operating purposes, until recently Ontario Hydro served the province through two separate networks of transmission lines and generating stations. A major line construction project launched in 1966 fully inter-connected the two systems. (See map, page 26).

Since formation, the Commission's growth has been remarkable. Power demands give every evidence of continuing to increase, not only because of population growth but also because the modern family, as well as industry, has come to depend more and more on the use of electricity.

Particularly notable has been the extension of electric power service to rural areas. Service is now available to 95 per cent of the farms of the province. In 1969, Ontario Hydro supplied, through its Area Offices, more than 570,000 rural customers over a total of 51,000



miles of rural line.

The total number of customers served by Ontario Hydro and the associated municipal electrical utilities exceeds 2.3 million.

## post-war expansion

Hydro's greatest period of expansion started in 1945. Freed from wartime restrictions on the use of manpower and materials, Hydro launched an extensive program to expand its facilities to meet customers' needs.

As few large-scale hydro-electric sites in the province remained undeveloped, studies began of the cost of steam-power generation. There would certainly be more emphasis on thermal-electric generation in the future.

The need for a change from a partly 25-cycle to virtually universal 60-cycle power system was also anticipated at this time because of the possibilities of exchanging power through interconnections with utilities in neighboring states or provinces. The change was important to consumers who were to benefit from the lower cost of 60-cycle equipment and appliances, and the greater dependability of service which would result from the interconnections. The standardization program, begun in 1949, was completed in 1959, placing virtually all of Ontario on 60-cycle power.

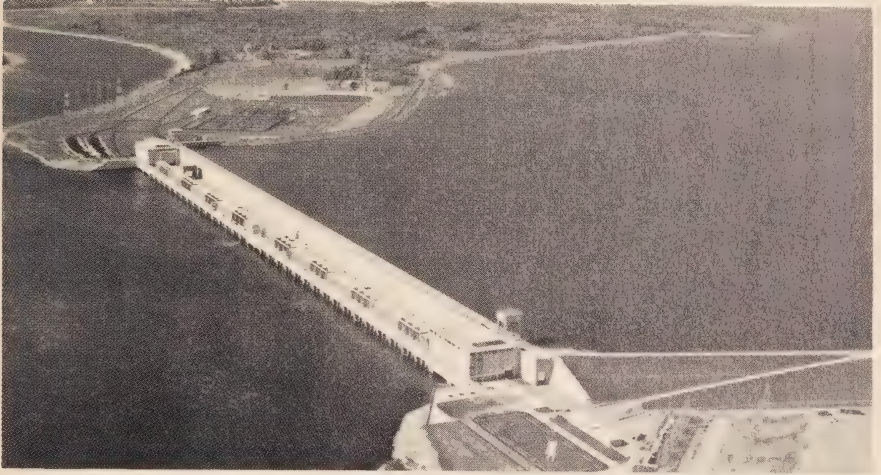
Between 1945 and 1969, Hydro brought into service 37 new sources of power involving 10,000,000 kilowatts, more than five times the 1945 figure.

Representing a departure from Hydro's long-standing pattern of hydro-electric development, the first two coal-fired thermal-electric stations went into service in 1951. The Richard L. Hearn Generating Station on the Toronto waterfront, and the J. Clark Keith station at Windsor today have a total capacity of 1,464,000 kilowatts.

The next big construction projects were major hydro-electric developments at Niagara Falls and on the St. Lawrence River. The Sir Adam Beck-Niagara Generating Station No.2 with an installed capacity of 1,400,000 kilowatts, first generated power in April, 1954. It consists of a 16-unit main powerhouse, together with an associated pumping-generating station. The unique pumping-generating scheme involves the storage of vast quantities of water for use during periods of highest power demand. It consists of a reversible-flow canal system and a huge storage reservoir as well as the pumping-generating facilities. During hours when electrical demand is lowest, the six reversible units at the pumping-generating station are used as pumps to fill the reservoir. Water is released from the huge reservoir during periods of highest power demand and the same units act as generators.

The St. Lawrence Power Project was undertaken jointly with the Power Authority of the State of New York. Ontario Hydro's section of the power dam is known as the Robert H.

*St. Lawrence Power Project was developed by Ontario Hydro and the Power Authority of the State of New York.*



Saunders-St. Lawrence Generating Station. Producing first power in July, 1958, this project tapped the last major source of hydro-electric power in Southern Ontario.

The emphasis on thermal-electric generation has increased steadily and by 1969 it represented approximately 44 per cent of Hydro's resources. Thermal-electric installations both fossil-fuel and nuclear, may represent 75 per cent by 1980. Fossil-fuel thermal-electric stations are suited to contribute to power supply at times of peak or greatest demand for electricity, and supplement hydro-electric generation during periods of low river flows. Because it would be uneconomic to operate nuclear-power plants during periods of peak demands only, full-scale thermal

stations of this type, such as Douglas Point, will be operated continuously to help meet constant demand levels known technically as "base loads".

Lakeview Generating Station, on the western outskirts of Metropolitan Toronto, delivered first power in 1961. With the progressive addition of new generating units, it reached its full capacity of 2,400,000 kilowatts in 1968.

The year 1963 saw commissioning of the 100,000-kilowatt Thunder Bay Generating Station at what was then Fort William. Construction of the system's fifth coal-fired station—near Courtright on the St. Clair River 14 miles south of Sarnia—started in 1965. First power at Lambton G.S., was produced in 1969. It consists of four generating units giving

MANITOBA

ONTARIO

JAMES BAY







## Legend

### Main Sources of Power

HYDRO-ELECTRIC	Thermal-ELECTRIC Conventional	Nuclear	CAPACITY IN KILOWATTS
			over 500,000
			100,000-500,000
			10,000-100,000
			under 10,000

### GENERATING STATIONS UNDER CONSTRUCTION

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### OR BEING EXTENDED

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### ROUTES OF MAIN POWER FLOW



### POINTS OF POWER INTERCHANGE



### MAIN UTILIZATION CENTRES



## Regions

①	Western	LONDON
②	Niagara	HAMILTON
③	Central	TORONTO
④	Georgian Bay	BARRIE
⑤	Eastern	BELLEVILLE
⑥	Northeastern	NORTH BAY
⑦	Northwestern	PORT ARTHUR

### REGIONAL BOUNDARIES



a total installed capacity of 2,000,000 kilowatts by 1970.

Construction started in 1968 on a \$678 million coal-burning plant at Nanticoke, a small Lake Erie community near Port Dover. First of the eight 500,000-kilowatt units is scheduled for service in 1971.

In Eastern Ontario, construction started at Lennox Generating Station, 22 miles west of Kingston, in 1970. With a capacity of 2,295,000 kilowatts, this will be the Commission's first major oil burning station.

As long ago as 1951, Ontario Hydro began to study the possibility of nuclear-electric power. Four years later, Hydro made an agreement with Atomic Energy of Canada Limited, and the Canadian General Electric Company, to design and construct a small station to gain practical experience.

The experimental project, known as the Nuclear Power Demonstration (NPD) Plant, was built at Rolphton, Ontario, near Hydro's Des Joachim's station on the Ottawa River. It began feeding power into the East System in 1962.

In 1959, Hydro entered into an agreement under which Atomic Energy of Canada Limited would proceed with a full scale station. With a capacity of 200,000 kilowatts, the Douglas Point Nuclear Power Station was constructed on the shore of Lake Huron, between Kincardine and Port Elgin. The station produced first power in January, 1967.

From NPD experience and cost estimates, it is apparent that the greatest reduction in nuclear power costs can be realized by increasing the size of the generating units and the

total capacity of the plant. The Canadian-type reactor, with its pressure tube system, lends itself readily to increases in size. From 20,000 kilowatts at NPD to 200,000 kilowatts at Douglas Point, the next step in Hydro's nuclear program – to 540,000-kilowatt units – was announced in 1964.

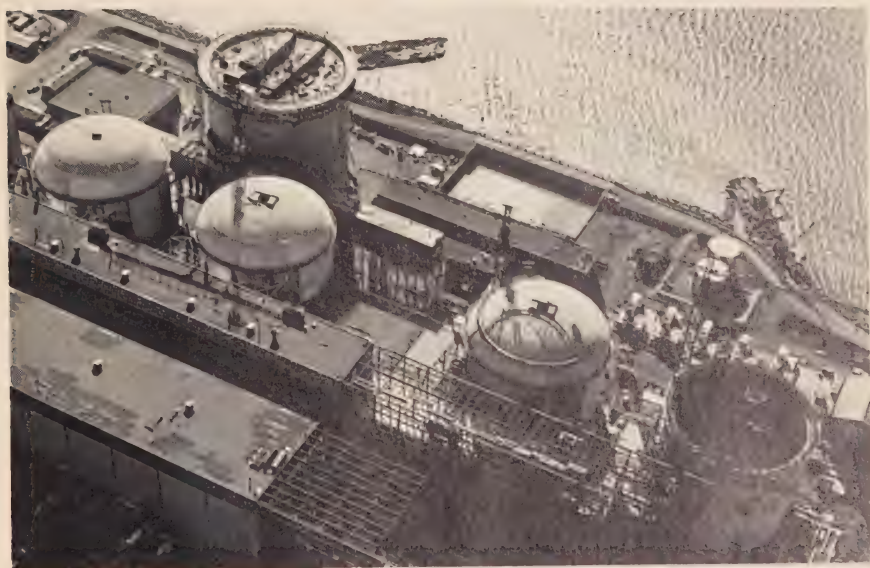
Four units of this size will be installed in a 2,160,000-kilowatt nuclear-electric station which Hydro is building in Pickering Township, 20 miles east of downtown Toronto on the shore of Lake Ontario. The first two units of the \$662,000,000 project are being jointly financed under an agreement between Hydro and the Ontario and Federal governments which will fully recover their contributions with interest. Cost of the next two units will be borne entirely by Ontario Hydro.

The plant is being built by Hydro with AECL acting as nuclear consultant. Pickering's four units are to be brought into service from 1971 to 1973. The station will be capable of serving the needs of 1.8 million households.

Late in 1968, Ontario Hydro announced plans to build a 3,200,000 kilowatt nuclear station near the existing Douglas Point plant. Called the Bruce Generating Station, is scheduled for completion in 1978 at a cost of \$944,000,000.

Situated between the two nuclear-electric station sites at Douglas Point, a heavy water production plant is rapidly taking form. Heavy water is essential to the operation of all nuclear power stations of the Canadian design. This plant will have an annual capacity of 800 tons of heavy water.

*Pickering Nuclear Power Station under development near Toronto.  
The bottom photo shows Hydro's giant, coal-burning Lakeview Generating Station*





It is slated to commence production in 1972.

It will be owned by AECL and operated by Ontario Hydro.

Thermal capacity exceeded Ontario Hydro's hydraulic resources for the first time in 1970. In the future by far the greatest part of the Commission's power resources will be thermal-electric, both coal-burning and nuclear.

Meanwhile, Hydro's development of new hydro-electric power sites continues. Three sites on the Madawaska River in Eastern Ontario—the new Mountain Chute development, and extensions to Barrett Chute and Stewartville Stations— totalling some 343,000 kilowatts were completed by 1969

In Northern Ontario construction of the 130,150-kilowatt Aubrey Falls project on the Mississagi River, 70 miles north of Thessalon, was completed in 1969. Downstream, the new 203,300-kilowatt Wells generating station commenced service in 1970.

On the Montreal River, 20 miles southeast of Cobalt, a 228,000-kilowatt station is to be completed at Lower Notch in 1971. In Northwestern Ontario, five small hydro-electric sites on the English, White and Little Jackfish rivers are possible future power sources.

To carry power economically from distant northern sites to the heavier population centres of Southern Ontario required higher voltages than Hydro had ever used before. After

experimenting with voltages up to 600,000 on a one-mile test line, Hydro began building the first major extra-high-voltage (EHV) transmission line in Canada, operating at 500,000 volts. The EHV line went into full operation in 1967.

Power from four hydro-electric stations on the Mattagami and Abitibi rivers, approximately 100 miles south of James Bay, is collected at nearby Pinard Transformer Station which is about 450 miles north of Toronto. From Pinard the EHV system brings the power to the Toronto area.

Northern communities receive power as needed from the plants through a connection near Sudbury. At times, the line also carries power from Southern Ontario to supplement the output of northern generating stations, ensuring additional security of electrical service to the north.

Ontario Hydro operates 68 hydro-electric, five coal-fired and two nuclear power stations, 165 transformer and 631 distributing stations, and 20,000 miles of transmission line. The original 14 municipalities which received power from Ontario Hydro have grown to more than 350, and the combined assets of the Commission and the municipal utilities served under cost contracts total more than \$4 billion.

Moreover, Ontario Hydro, either directly or through the municipal electrical utilities, is meeting 90 per cent of the provincial requirements for electricity. The remaining 10 per cent is provided by private utilities and companies generating power mainly for their own requirements.

## pattern of the future: quest for efficiency

In its quest for efficiency and a high standard of service, Hydro has pioneered in such areas as long-distance and extra-high-voltage transmission, helicopter patrols, wide-tracked muskeg vehicles and motorized cable cars for line work. As a result, electric energy is almost universally available in the province at less cost than in most places in the world. Even more exciting and challenging days lie ahead for Hydro as it enters the 1970's

In the age of space ships, communication satellites, computers and nuclear power, Hydro planners face ever-increasing demands for electric energy. It's estimated that by 1980 Hydro will require about 28,000,000 kilowatts, more than three times its 1967 capacity. Half a century ago some believed Niagara Falls was adequate to supply Ontario's needs for all time. In fact, Hydro must produce as much power as 14 Niagaras by 1980.

At the same time, Ontario Hydro is caught up in an era of rapid technological change. In 1970 thermal-electric generation surpassed hydro-electric for the first time. By the 1980s thermal power, both fossil-fuelled and nuclear, will supply at least three-quarters of Ontario's requirements. The increasing size of steam-powered units illustrates the pace of change. In 1950 Hydro began to install 100,000-kilowatt units in the

*Hydro helicopters helped construct extra-high-voltage line.*



Richard L. Hearn plant on the Toronto waterfront.

The Lakeview station, west of Toronto, has 300,000-kilowatt units. One of the four 500,000-kilowatt units for the Lambton station near Sarnia provides enough power to meet the requirements of over 300,000 homes. The Bruce nuclear power station will have four 800,000 kilowatt turbo-generators.

To transmit large blocks of power over long distances, Hydro engineers are planning extensions of the extra-high-voltage system. Even higher voltages than 500,000 now used to transmit alternating current power from the James Bay watershed to the Toronto area may be necessary in the next decade. At the same time Hydro is studying the possible advantages of extra-high-voltage direct current transmission if, for example, large blocks of power become available from Manitoba or Quebec.

The future will also likely see extensions of Hydro's network of interconnections with neighboring utility systems in the United States and Canada because of such mutual advantages as the economic exchange of power and assistance in emergencies.

The search for efficiency and security of service extends to the distribution of electricity. Many municipal utilities have installed underground systems in the core area of cities and in subdivisions—a long-range trend whose pace will depend on costs which are now significantly higher than for overhead lines. However, technological developments may well reduce these costs and speed the growth of underground distribution services.

As Ontario's power system expands there's need for a growing network of communications to help Hydro operate efficiently. At present Hydro has three separate communications networks—plus backup systems—which are continually being expanded to improve service within Hydro and ultimately to customers.

Besides telephones, Hydro uses teletype, taped data transmitters, microwave radio, fixed and mobile radio stations, public address systems and a growing number of walkie-talkie and pocket paging devices. Power lines themselves offer many communication channels for voice, telemetering, load control, protective relaying and other system control work.

Hydro engineers are actively studying an expansion of microwave facilities to provide the additional communication channels needed to improve security for a growing system.

Another sign of the times is the increasing use of computers for a wide range of tasks. Hydro installed its first electronic data processing equipment in 1958 and has steadily expanded its computer facilities and services. Now "third generation" computers—with advanced solid state circuitry which results in speeds of a billionth of a second—are in operation. Remote access terminals give engineers and research workers quick access to a central machine to solve problems. Smaller computers have been ordered for monitoring and controlling large generating stations and coal-handling facilities.

In fact, technology is making such rapid advances that computers will undoubtedly play an increasingly important role in Hydro's future. They will help Hydro to operate more efficiently in a complex electrical world that requires an increasing degree of automation to generate, transmit and distribute power over a province larger than Texas.

Meanwhile, the search for new



*Hydro makes extensive use of latest "3rd generation" computers.*



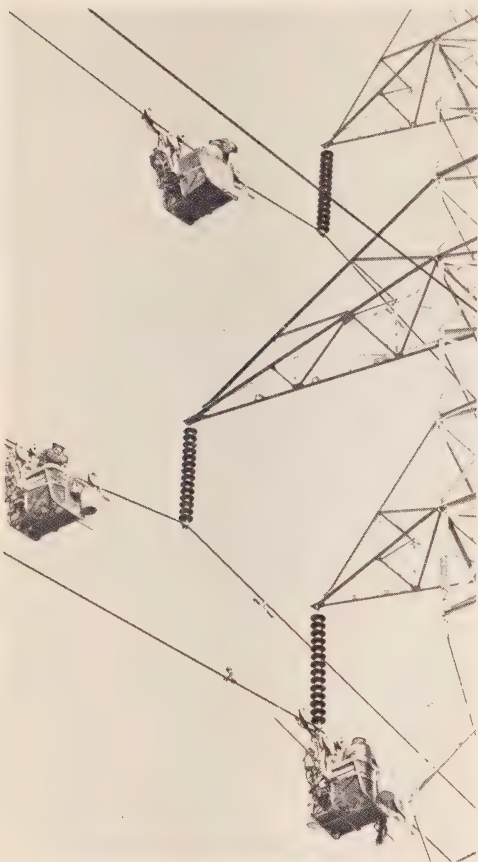
techniques goes on. Helicopters are lowering linemen onto live power lines for maintenance to avoid interruptions. Construction forces, assisted by larger machines, use modern methods to build power stations and transmission lines in hot or sub-zero weather. And every year Hydro's research laboratories carry out scores of projects to test new materials, solve problems and find better ways to do things.

Among many other problems, Hydro's researchers are working on efforts to minimize air pollution caused by coal-fired plants. They are members of a task force of specialists in medicine, biology, meteorology, engineering design and chemistry which is

constantly evaluating new ways to combat pollution. Hydro's clean air program, which started in 1949 with construction of the first large thermal- electric station, involves almost \$40 million for existing coal-fired plants.

Although Hydro plants don't pollute water, water pollution causes operational problems because thermal stations need large amounts of cooling water. Weeds sucked into water intakes can plug boiler feed pumps and cause a shutdown of generating units. And water used to create steam must be carefully processed in a station's water treatment centre under the supervision of chemists to protect

*Cable cars on high-voltage lines illustrate advanced techniques developed by Hydro.*



water intakes can plug boiler feed pumps and cause a shutdown of generating units. And water used to create steam must be carefully processed in a station's water treatment centre under the supervision of chemists to protect expensive equipment and ensure plant efficiency.

But the search for efficiency doesn't end with squeezing as many kilowatts as possible from a cubic foot of water, a lump of coal or a uranium fuel pellet. Hydro must encourage use of electricity so that large generating units, essential to meet peak demands, will not stand idle at other times during the day. Efficient use of equipment, in which utility customers have an investment, ensures low unit cost for electric energy and relieves the upward pressures on rates caused by rising prices for most goods and services. A well-directed marketing program irons out the peaks and fills up the valleys caused by fluctuating power demands.

In the past, Ontario has enjoyed higher per customer electric power consumption and lower costs than its U.S. neighbors—a trend that will likely continue. But as the emphasis on thermal-electric power grows, the gap between rates in Canada and the U.S. will narrow. Thus Ontario Hydro must search out new techniques and economies to maintain its favorable position. By doing so, it will be fulfilling its continuing responsibility to provide an abundant supply of electric power for a growing province at low cost.

That's the challenge of the future.

## chronology

**1906** Royal assent given to an Act of the Ontario Legislature creating The Hydro-Electric Power Commission of Ontario. The Act provided for the appointment, by the Lieutenant-Governor in Council, of a commission consisting of three persons.

The first Commission was appointed: Adam Beck, Chairman; J.S. Hendrie and Cecil B. Smith, Commissioners.

**1907** The Power Commission Act becomes law. This was a re-enactment of the Act of 1906, which was repealed. Ontario Hydro continues to operate under The Power Commission Act as amended.

The Commission signs contract with the Ontario Power Company to supply up to a maximum of 75,000 kilowatts.

**1908** Fourteen municipalities enter into an agreement with the Commission for a total of 19,571 kilowatts of electric power.

**1910** A special ceremony at Berlin (now Kitchener) on October 11 marks delivery of first power by the Commission. While Berlin was the first of the 14 contracting municipalities to receive electric power service on a cost basis, power was supplied, before the year was out, to Guelph, Waterloo, Preston, London, Woodstock, Hamilton, Stratford and Port Arthur.

**1911** The Power Commission Act amended to facilitate rural electrification.

**1912** Ontario Hydro undertakes electrical inspection throughout the province.

**1913** Tenders called for the dam and powerhouse of the first hydro-electric power development to be constructed by the Commission, Wasdell Falls on the Severn River. The station began operating in October, 1914, with a capacity of 750 kilowatts.

**1916** The Commission moves into a new administration building on University Avenue, Toronto. Hydro extends service into Northeastern Ontario by assuming responsibility for operating the Nipissing Power Company, North Bay.

**1917** Construction starts on the Queenston-Chippawa development, now known as Sir Adam Beck-Niagara G.S. No.1. The first unit was placed in service in January, 1922.

The Commission purchases the Niagara plant of the Ontario Power Company (135,000 kilowatts), the first source of Niagara power to supply Ontario Hydro customers.

**1921** The Rural Hydro-Electric Distribution Act authorizes provincial government payments to Ontario Hydro of up to 50 per cent of the capital cost of all primary lines for rural service. In 1924, the Act was amended to include payments for transformers and secondary equipment.

**1925** Sir Adam Beck, Hydro's first Chairman, dies.

**1926** The Commission enters into a long-term contract to obtain power from the Gatineau Power Company of the Province of Quebec.

**1929** The Commission enters into a contract with the Beauharnois Light, Heat and Power Company in the Province of Quebec to provide



186,500 kilowatts to the Niagara System.

**1933** Flat-rate water heating inaugurated.

**1940** The Canadian Standards Association assumes from Ontario Hydro the responsibility of approvals testing of electrical equipment.

**1944** Amalgamation of the whole rural service into one rural power division of Ontario Hydro becomes effective. The change introduces a common rate for each class of service, except industrial customers.

The Southern Ontario System was created by the amalgamation of the Niagara, Georgian Bay and Eastern Ontario divisions.

**1945** Hydro assumes operation of the facilities of the Northern Ontario Power Company, including eight hydro-electric stations and 12 municipal distribution systems in Northeastern Ontario.

**1947** The Commission establishes nine regions in the province which are eventually reduced to seven.

**1948** The Power Commission Act amended to pave the way for frequency standardization in the 25-cycle area of Southern Ontario. The program officially began in October, 1949.

**1949** Work starts on the J. Clark Keith Generating Station in Windsor, the first of Hydro's major thermal-electric plants.

Work begins on the Richard L. Hearn thermal-electric generating station, located on Toronto's waterfront.

**1950** The Niagara Diversion Treaty, ratified by Canada and the United States, enables Ontario Hydro to proceed with construction of the Sir Adam Beck-Niagara G.S. No.2.

**1953** Official ceremonies mark an international exchange of power between Ontario Hydro and the Detroit Edison Company.

**1954** The U.S. Federal Power Commission approves a power exchange agreement between Ontario Hydro and the Niagara-Mohawk Power Corporation.

A sod-turning ceremony officially starts the St. Lawrence Power Project. The Duchess of Kent officially opens the Sir Adam Beck-Niagara G.S. No.2.

**1955** The Ontario Government announces an increase in Commission membership from three to a maximum of six.

**1956** Ontario Hydro marks a half-century of service to the people of the province.

Sod-turning ceremonies held for the Nuclear Power Demonstration plant at Rolphpton, on the Ottawa River.

**1958** First power from the St. Lawrence power development generated in the Robert H. Saunders-St. Lawrence Generating Station, the Canadian section of the international structure.

Major equipment for a data processing system delivered to Ontario Hydro head office.

**1959** The Federal Government announces that Atomic Energy of Canada Limited would build a full-scale nuclear power station which upon completion would be operated by Ontario Hydro. Douglas Point on the shore of Lake Huron was chosen as the site.

A ceremony at a private home in the Toronto area marks completion of the frequency standardization program, the largest project of its kind ever undertaken.

**1960** The Commission announces that, as part of its plan for construction of three new hydro-electric plants on the Mattagami River, in Northeastern Ontario, an extra-high-voltage system would be built, the first major 500,000-volt line in Canada.

Construction starts on 200,000-kilowatt Douglas Point Nuclear Power Station.

**1961** Otter Rapids Generating Station on the Abitibi River delivers first power.

Construction starts on 435-mile, 500,000-volt EHV line from Pinard, 60 miles north of Cochrane, to Toronto area.

Largest single generating unit in Canada—300,000 kilowatts—begins producing electricity at Lakeview Generating Station.

**1962** NPD, Canada's first nuclear-electric station, at Rolphton, placed in operation.

Extension of the international, interconnected utility system, of which Ontario is an integral part, from northern Ontario to the Gulf of Mexico and from the Rocky Mountains to the Atlantic Ocean.

**1964** Plans announced for new coal-fired station near Sarnia.

Lambton Generating Station will be generating 2,000,000 kilowatts by 1970.

New 1,080,000-kilowatt nuclear-power station authorized for Pickering Township, 20 miles east of downtown Toronto.

Excavation starts for 139,500-kilowatt Mountain Chute hydro-electric station on Madawaska River near Renfrew.

**1965** Harmon Generating Station, on the Mattagami River, produces first power.

Plans announced for extensions to Barrett Chute and Stewartville Generating Stations on the Madawaska River.

Major power interruption on November 9.

**1966** Ontario Hydro marks its 60th anniversary.

George E. Gathercole becomes Ontario Hydro's 10th Chairman, succeeding W. Ross Strike.

Plans announced for interconnection between Hydro's East and West Systems; new Aubrey Falls hydro-electric station on the Mississagi River.

Canada's first full-scale nuclear-electric generating station, Douglas Point, goes critical.

Three Mattagami River hydro-electric plants officially opened, including Kipling Generating Station which delivered first power.

**1967** Entire 435-mile EHV line operates at 500,000 volts, highest in Ontario.

Hydro announces plans to double size of Pickering Nuclear Power Station to 2,160,000 kilowatts, to build new coal-fired Nanticoke station near Port Dover which will produce 2,000,000 kilowatts by 1974 and two new hydro-electric plants on Montreal and Mississagi rivers.

Douglas Point Nuclear Power Station produces first electric power.

**1968** Plans announced for Bruce nuclear-electric station to produce 3,200,000 kilowatts by 1978; AECL to build 800-ton-a-year heavy water plant nearby.

Oil-fired Lennox Generating Station (2,295,000 kilowatts) planned near Kingston.

All eight Lakeview units in service.

**1969** Aubrey Falls hydro-electric plant and extension to Stewartville station completed.

Construction starts on second EHV line between Sudbury and Toronto.

Coal-fired Lambton station produces first power.

**1970** Nanticoke station capacity to be doubled to 4,000,000 kilowatts by 1977.

Interconnection between East and West systems completed.

## the municipal utilities

The Hydro-Electric Power Commission of Ontario – or Ontario Hydro as it is familiarly known – is responsible for the generation and transmission of electric power and its sale to co-operating municipal electrical utilities. At the same time, it acts as a central supervisory body with power to approve and control certain features of the utilities' operations.

In most cities and towns, in many villages and in some heavily-populated township areas, the retail distribution of power is the responsibility of the municipal electrical utilities, which own and operate the distribution systems. The co-operating municipalities obtain their supply of power from Ontario Hydro at cost.

Any incorporated municipality (city, town, village or township) may apply to Ontario Hydro for a supply of power. The corporation is required to obtain approval of its electors, after which the council may pass a bylaw authorizing the corporation to enter into a contract with Ontario Hydro.

All co-operating municipalities are supplied with power under similar contracts. Providing power at cost was a condition of the first contracts signed by Ontario Hydro in 1908 with the original 14 participating municipalities.

The broad, general supervision which the provincial Commission exercises over the municipal electrical utilities is set forth in two provincial acts, The Power Commission Act and The Public Utilities Act. These acts also set out the duties and responsibilities of the provincial body and the local

*Civic celebrations marked the advent of Hydro power in Kitchener on October 11, 1910.*





*Modern equipment helps municipal utilities provide first class service.*



commissions. The municipalities usually form commissions, known either as a Hydro-Electric or a Public Utilities Commission, for the purpose of administering the service to customers within the municipal boundaries.

Ontario Hydro, as a publicly-owned utility, makes no profit. The price paid for power by the utilities includes the cost of establishing reserves, as well as such items as generated and purchased power, operating and maintenance charges and interest on capital investment. Financial reserves are provided for such things as depreciation, obsolescence and contingencies, as well as being used as a sinking fund for retirement of capital expenditures.

Since costs cannot be determined precisely until an analysis has been made of Ontario Hydro's operations for the fiscal year, power supplied is billed monthly at an interim rate. At the end of the fiscal year, the actual cost of power is determined. Then a credit or debit adjustment—commonly known as "the 13th power bill"—is made to each cost-contract municipal electrical utility. The 13th bill is an essential fulfillment of the co-operative nature of the Hydro enterprise.

The municipal utilities obtain money for capital costs for their own distribution systems from the municipal corporations through the sale of municipal debentures or from revenues the utilities do not require for current operating expenses. Resale rates include provision for sufficient revenue to pay the interest on these debentures in addition to the sum necessary to retire the debentures

within a specified period.

The municipal commission engages its own staff of qualified personnel to handle technical and administrative work. The utility is required to maintain a system of uniform accounts to provide in detail the requirements set out in The Power Commission Act. A uniform system is essential to ensure proper accounting for a utility's costs and the maintenance of a fair retail rate.

Its accounts are audited by Ontario Hydro's accounting staff to establish and maintain this uniformity, but this practice does not relieve the municipal utility of responsibility to the municipal corporation. Under The Public Utilities Act, each municipal commission is responsible for an annual accounting of its affairs to the municipal Council, and the utilities' accounts are subject to municipal corporation audit.

Surpluses, however, cannot be requisitioned by the municipal corporation, and may be applied only to the operation of the electrical utility. The utility may use funds not required for current operating expenses for the retirement of indebtedness, erection of utility buildings, extension of works, the purchase of securities, etc., all subject to approval by Ontario Hydro. The purchase of securities is limited to the bonds of Canada, of the Province of Ontario, or securities guaranteed by their governments.

With few exceptions, utilities have been able to operate and provide for expansion on revenues of 10 per cent in excess of total expenses. In favorable circumstances, the utility's operating surplus will often increase beyond the 10 per cent originally

*Street lighting standards have been greatly improved across the province.*



estimated. In this event, Ontario Hydro reviews the utilities' resale rates with a view to working with the utility to effect a rate reduction.

Besides the municipalities which have signed contracts, Ontario Hydro serves some direct industrial customers, with high demands or located in areas not served by municipal utilities; rural customers; and urban customers in a few municipalities where Ontario Hydro owns the distribution system.

The Commission obtains funds required for capital expenditures by issuing bonds. Prior to 1934, these bonds were issued by the province and the funds were advanced to Ontario Hydro, which became responsible for discharging the debt. Since 1934, the bonds have been issued in Canada by Ontario Hydro. When it has been necessary, because of market conditions, to raise money in the United States, it has been done by the province on the Commission's behalf.

Provision is made in Ontario Hydro's wholesale power rates for the amount necessary to retire this debt over a period of 40 years from the date of its issue.

Funds which are raised in this manner are used for the construction and

acquisition of plant, the provision of working capital, and purchases of coal, material and supplies, and tools and equipment.

Ontario Hydro has the responsibility for the inspection of electrical wiring and electrical equipment in the province. Under provincial regulations, inspection of all new electrical installations and alterations is compulsory. The inspection staff also undertakes house-to-house inspections, in close co-operation with local authorities, to uncover potential sources of danger.

The safety of electrical equipment, or appliances offered for sale, is established either by inspection of particular units or by adoption of the approvals reports of the Canadian Standards Association, which maintains extensive laboratories for testing purposes. Ontario Hydro's Electrical Inspection Department is responsible for preventing the sale of equipment not properly approved.

In cities with over 60,000 population, The Power Commission Act permits members of the municipal commission to be appointed by the City Council and Ontario Hydro; and in some townships and villages the local commission may be a committee of the municipal



council. In the vast majority of cases, however, members of the municipal commission are elected.

Members of the Ontario Hydro Commission are appointed by the Lieutenant-Governor in Council. At present, the Commission comprises a chairman, two vice-chairmen and two commissioners. Headquarters of Ontario Hydro is in Toronto, with the main administration building at 620 University Avenue.

### power partners



Two allied organizations, along with Ontario Hydro, form a unique three-way partnership. For more than 50 years they have been active in maintaining and safeguarding the Hydro interests of the municipalities and promoting the

successful operation of the Hydro enterprise.

The Ontario Municipal Electric Association, representing more than 350 Hydro utilities, is composed of local Hydro commissioners—all but a few are elected. The Association of Municipal Electrical Utilities represents the management and senior operating staffs who are appointed to carry out the policies of municipal systems.

Through regular district meetings and committees these associations deal with matters of vital importance to their local utilities and Ontario Hydro, such as legislation, customer relations, sales promotion, underground wiring, accident prevention, system planning, communications and rates.

Each year delegates from all over the province convene in Toronto for the OMEA's annual meeting, which is held in conjunction with the AMEU. This meeting, like a Provincial Parliament of Electric Power, brings together about 1,500 delegates whose deliberations have an important bearing on Hydro policy.

In this way the elected and appointed representatives of the municipalities have a strong voice in shaping Hydro policies for the benefit of their individual municipalities and their customers.

This three-way partnership fosters united action in a fast-moving age of stiff competition and rapid technological change.

Together these organizations face the challenges involved in operating efficient, well-run utilities well tuned to serve the electrical needs of their customers.

*definitions of the more common electrical terms*

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**ALTERNATING CURRENT** A periodic current which has alternately positive and negative values. Abbreviated a-c (as an adjective).

**AMPERE** The unit of electric current. It is a measure of the time rate of flow of electricity through a conductor. Abbreviation, amp.

**BASE LOAD** That part of the total demand which is continuous, as distinguished from that which fluctuates widely as the total system demand changes from hour to hour or seasonally. (See peak demand).

**BUS** An electrical conductor which serves as a common connection for two or more electrical circuits. These conductors are usually rigid bars.

**CAPACITOR** An apparatus for the accumulation of electricity, usually consisting of conducting plates separated by insulating material. Also called condenser. It has many functions, depending mainly on the type of power circuit in which it is employed and the purpose to which the accumulated electricity is to be directed.

**CIRCUIT** The conductors through which an electric current is intended to flow.

**CONDENSER** Apparatus containing miles of tubing in which steam exhausted from a turbine is condensed to water for re-use in a thermal-electric station. See also capacitor, synchronous condenser.

**CONDUCTOR** An electrical path which offers comparatively little resistance to the flow of electricity. Copper, aluminum, silver and gold are among the best conductors.

**CYCLE** One complete set of positive and negative values of alternating current. A cycle usually consists of one positive pulse followed by one negative pulse. (See frequency).

**DEPENDABLE PEAK CAPACITY** The net output of power which a generating station can be expected to supply at the time of the peak demand. (See installed capacity).

**DIRECT CURRENT** An electric current which flows in one direction. Abbreviated d-c (as an adjective).

**DISTRIBUTION LINE** A line used for distributing electric energy over a short distance. The voltage is usually less than that of a transmission line.

**EHV** On the North American continent, Extra High Voltage is considered to be 345,000 volts and up.

**ELECTRIC** In the electrical industry a distinction is often made between electric and electrical. Electric means containing, producing, arising from, actuated by, or carrying electricity, or designed to carry electricity and capable of doing so. Examples: Electric eel, energy, motor, stove, vehicle, wave.

**ELECTRICAL** means related to, pertaining to, or associated with, electricity, but not having its properties or characteristics. Examples: Electrical equipment and appliances, engineer, handbook, insulator, rating, school, unit.

**ELECTRIC CURRENT** The flow of electric particles (usually electrons) in a conductor. (See electron).

**ELECTRIC ENERGY** The ability of an electric current to do work. (See electric current, kilowatt-hour).



**ELECTRICITY** Electricity is one of the fundamental quantities of the atomic structure of matter and is conceived of as elementary particles designated as positive and negative electricity. The negative particles (electrons) in conductors are relatively mobile and can be set in motion by the expenditure of energy to create an electric current.

**ELECTRON** A particle carrying a negative charge of electricity that whirls about the centre of an atom like the earth circles the sun.

**FISSION** (See nuclear energy).

**FREQUENCY** The number of cycles of alternating current which occur in one second. Electric power frequency in North America is usually 60 cycles per second, abbreviated cps or c. A hertz is one cycle per second.

**GENERATOR** A machine for transforming mechanical energy into electric energy.

**HEADPOND** A reservoir or pond at the head of a penstock or pipeline.

**HORSEPOWER** A rate of working. It is equal to 550 foot-pounds per second. One horsepower is also equal to 746 watts.

**HYDRO-ELECTRIC GENERATING STATION** A station in which the force of falling water spins turbines to drive electric generators. This is a general term for a powerhouse, dam, headpond and a means of carrying water from the headpond to the powerhouse.

**INSTALLED CAPACITY** The total of the capacities as shown by the name plates of the generating units in a

station or system. (See dependable peak capacity).

**INTERCONNECTION** Conductors linking two power systems, such as Ontario Hydro and a neighboring utility in Canada or the United States, which are usually electrically synchronized.

**KILOWATT** 1,000 watts. Abbreviated as kw.

**KILOWATT-HOUR** The basic unit of electric energy equal to one kilowatt supplied steadily for one hour. It is abbreviated by Ontario Hydro as kwh.

**KILOVOLT-AMPERE** A measure of the apparent, as opposed to the true power, in an electric circuit. It is obtained by multiplying the voltage by the amperage. Abbreviation: KVA.

**LOAD** The power requirement (usually measured in kilowatts) of a system or a piece of equipment at a given instant, or the average rate of energy consumption during a designated period of time.

**LOAD FACTOR** The ratio of the average power demands over a designated period of time to the peak load occurring in that period.

**MECHANICAL ENERGY** The work done by the action of a mechanical force, measured as the product of the force and the distance through which it acts.

**MEGAWATT** 1,000 kilowatts or 1,000,000 watts. Abbreviated as Mw. A gigawatt is 1,000,000 kilowatts; a terawatt equals 1,000,000,000 kilowatts.

**METER** An intricate mechanism, made

with watch-like precision, that measures in kilowatt-hours the amount of electric energy used by a customer. An act of the Federal Government requires the inspection and calibration of meters every six to eight years to ensure accuracy. Sometimes called a watt-hour or a kilowatt-hour meter.

**OHM** The unit of electric resistance. It is the resistance of a circuit which has a potential difference of one volt between its ends and a steady current of one ampere flowing through it.

**PEAK DEMAND** The maximum demand for power (measured in kilowatts) which occurs within a stated period of time. Ontario Hydro, which uses time periods of ten and twenty minutes, finds that normally the system peak demand takes place during December. (See base load).

**PENSTOCK** A closed conduit for supplying water under pressure to a turbine. Large penstocks are usually made of curved steel plates embedded in concrete.

**POWER FACTOR** A measure of the efficiency of a circuit, usually expressed as a percentage.

**PRIMARY LINES** Lines and equipment in rural and municipal distribution systems, most of which are operated at levels ranging between 4,000 and 13,800 volts. (See secondary lines).

**RECTIFIER** An electrical apparatus which will pass electric current through in only one direction. It is thus employed to change alternating current to direct current.

**RESISTANCE** That property of a

circuit by which it resists the flow of electricity and causes energy dissipation in the form of heat. Resistance is usually measured in ohms.

**SCROLL CASE** A spiral conduit of diminishing circumference through which water impinges on a turbine water wheel. It is so designed that the impact of the water is equal at all points around the water wheel.

**SECONDARY LINES** Lines, transformers and other customer service equipment operating on voltages at which the customer receives electric power at 120,240 or 600 volts.

**SINGLE-PHASE POWER** A wave of power in which the voltage (or pressure) pulsates 25 or 60 cycles each second. Household service, always single-phase, consists of three wires—two conductors and a neutral.

**STEP DOWN** A reduction in voltage, as through a step-down transformer.

**STEP UP** An increase in voltage, as through a step-up transformer.

**SYNCHRONOUS CONDENSER** A rotating machine used for regulation of voltage on electric power systems.

**TAILRACE** A channel conducting water away from a hydro-electric plant.

**THERMAL-ELECTRIC GENERATING STATION** A generating station using heat for producing steam to rotate a turbine, which in turn drives an electric generator. The conventional fuels used to create heat are coal, oil or gas. Nuclear reactors are now being used as heat source.

**THREE-PHASE POWER** Three-phase supply minimizes the pulsating effect of alternating current by introducing successive waves of power. As in a gasoline engine where one or more pistons is always firing, power is supplied continuously. Motors with more than 100 horsepower operate more efficiently on three-phase power, which is supplied by three conductors and a neutral wire.

**TRANSFORMER** An electro-magnetic device for changing alternating-current electricity to either higher or lower voltage. Transformers make possible transmission of power over long distances.

**TRANSMISSION LINE** The conductors and their supporting structures, used to convey electric energy from a generating station to a distant point.

**TURBINE** A rotating machine for transforming the energy of steam, gases or falling water into mechanical energy.

**VOLT** The unit of electric pressure. One volt is the force which will produce a current of one ampere if steadily applied to a circuit having a resistance of one ohm. A kilovolt is 1,000 volts.

**WATT** The basic unit of electric power, expressing the rate at which electric energy is being expended. Power in watts equals the current in amperes times the voltage in volts. Abbreviated as w.

## NUCLEAR ENERGY

**ATOM** A small particle of matter that can't be seen. An atom is so tiny there are millions in a grain of salt and billions in a drop of water. The only atom in nature that can easily be split or fissioned is the uranium atom U-235.

**ELECTRON** Part of every atom. It is negatively charged electrically and whirls about the centre of an atom like the earth circles the sun. A uranium atom has 92 electrons.

**NUCLEUS** The heart or centre of an atom, usually composed of one or more neutrons and one or more protons. A U-235 atom has 92 protons and 143 neutrons.

**NEUTRON** Part of an atom's nucleus which has no electric charge. It starts fission when it hits a U-235 atom.

**PROTON** Part of an atom's nucleus which is charged positively and so keeps the electrons, which are charged negatively, in orbit.

**URANIUM** An ore found in abundance in Ontario. Natural uranium oxide is being used as a fuel in Canadian nuclear reactors.

**HEAVY WATER** Ordinary water ( $H_2O$ ) is two parts hydrogen and 1 part oxygen but heavy water contains "heavy" hydrogen. It looks, tastes and smells like water. Canadian nuclear reactors use heavy water as moderator and coolant. Technical name: Deuterium oxide ( $D_2O$ ).

**REACTOR** A structure, usually a cylindrical tank, in which uranium atoms fission to cause controlled heat.



**CHAIN REACTION** A neutron causes a U-235 atom to fly apart, or fission. This creates other free neutrons that cause other U-235 atoms to fission. So begins a chain reaction. A controlled reaction gives off heat which produces steam to drive turbo-generators in a nuclear power station.

**NUCLEAR ENERGY** The energy freed by nuclear fission. Also known as "atomic energy", a less precise term.

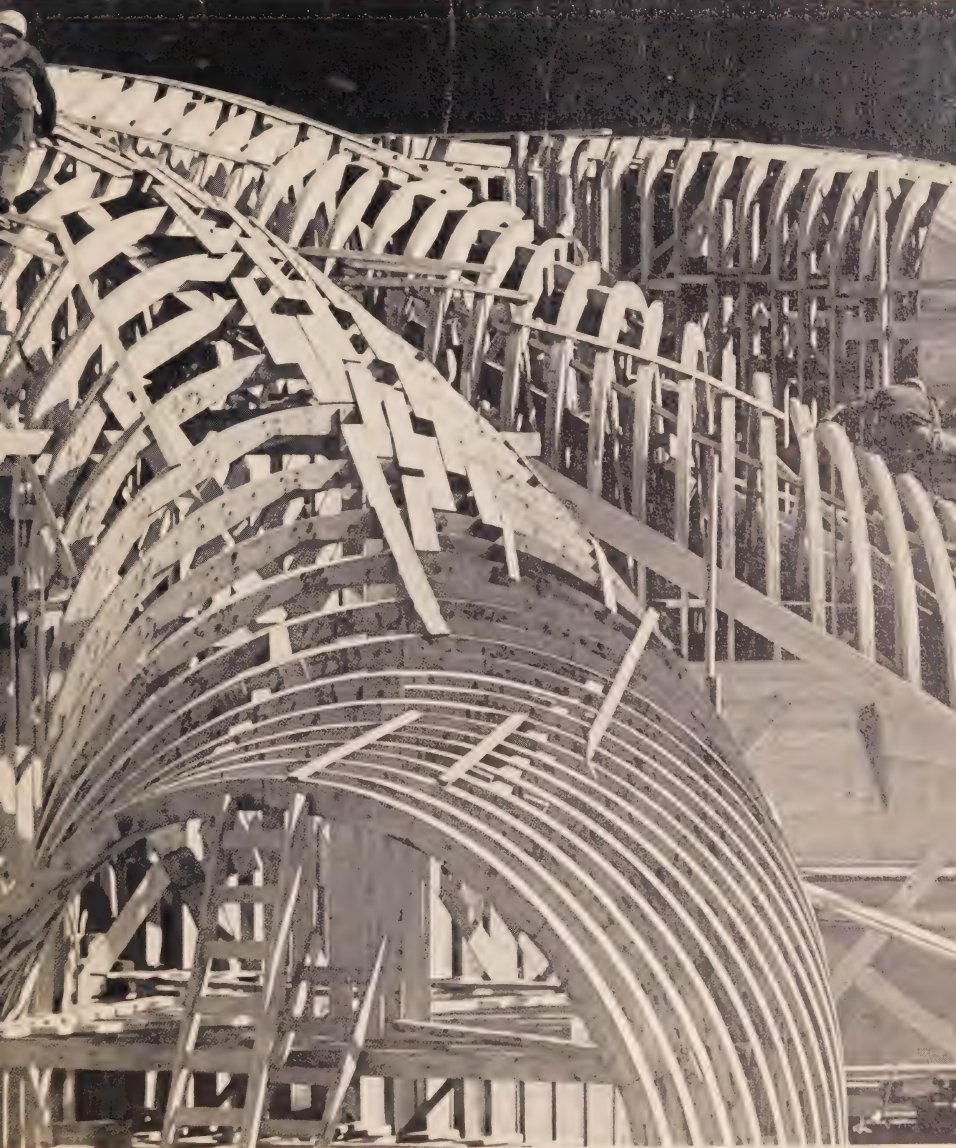
**NUCLEAR FISSION** The splitting of an atomic nucleus into pieces. This results in emission of neutrons and release of energy which cause a chain reaction.

**NPD** Nuclear Power Demonstration plant, located on the Ottawa River at Rolphton, now sending 20,000 kilowatts of electric power into Ontario Hydro lines. It has a heavy water cooled, heavy water moderated reactor in which the fuel is natural uranium oxide.

**CANDU** Type of reactor used in 200,000-kilowatt Douglas Point Nuclear Power Station, between Port Elgin and Kincardine, and scheduled for installation in 2,160,000-kilowatt Pickering Station near Toronto.

# generating stations

*Intricate formwork for generating station suggests vital role water power continues to play in Hydro system.*



## ontario hydro generating stations

hydro-electric stations	river	placed	acquired	installed
		in service		capacity kilowatts
Abitibi Canyon	Abitibi	1933	1933	210,100
Aguasabon	Aguasabon	1948		40,500
Alexander	Nipigon	1930		65,300
Aubrey Falls	Mississagi	1969		130,200
Auburn	Otonabee	1911	1916	1,900
Barrett Chute	Madawaska	1942		152,400
Sir Adam Beck-Niagara No.1	Niagara	1922		403,900
Sir Adam Beck-Niagara No.2	Niagara	1954		1,400,300
Big Chute	Severn	1909	1914	4,000
Big Eddy	Muskoka	1941		7,700
Bingham Chute	South	1923		800
Calabogie	Madawaska	1917	1929	4,000
Cameron Falls	Nipigon	1920		72,000
Caribou Falls	English	1958		77,000
* Chats Falls	Ottawa	1931		178,600
Chenau	Ottawa	1950		122,400
Coniston	Wanapitei	1905	1930	4,100
Crystal Falls	Sturgeon	1921	1937	8,100
DeCew Falls No.1 (old plant)	Welland Canal	1898	1930	31,900
DeCew Falls No.2 (new plant)	Welland Canal	1943		115,200
Des Joachims	Ottawa	1950		360,000
Ear Falls	English	1929		18,600
Elliott Chute	South	1929		1,400
Eugenia	Beaver	1915		4,800
Fountain Falls	Montreal	1914	1944	2,000
Frankford	Trent	1913	1916	2,600
Galetta	Mississippi	1907	1929	800
Hagues Reach	Trent	1925		3,400
Hanna Chute	S. Muskoka	1926		1,100
Harmon	Mattagami	1965		129,200
Heely Falls	Trent	1913	1916	10,500
High Falls	Mississippi	1920		2,100
Otto Holden	Ottawa	1952		205,200
Hound Chute	Montreal	1910	1944	2,800
Indian Chute	Montreal	1923	1944	3,200

\* Chats Falls is owned jointly by Ontario Hydro and the Ottawa Valley Power Company. The entire output of the plant is available to Ontario Hydro.



hydro-electric stations	river	placed in service	acquired	installed capacity kilowatts
Kakabeka Falls	Kaministiquia	1906	1949	24,200
Kipling	Mattagami	1966		125,400
Lakefield	Otonabee	1928	1936	2,000
Little Long	Mattagami	1963		121,600
Lower Sturgeon	Mattagami	1923	1944	6,400
McVittie	Wanapitei	1912	1930	2,300
Manitou Falls	English	1956		72,000
Matabitchuan	Matabitchuan	1910	1944	6,800
Merrickville	Rideau	1915	1949	800
Meyersburg	Trent	1924		4,800
Mountain Chute	Madawaska	1967		139,500
Nipissing	South	1909	1916	2,100
Ontario Power	Niagara	1905	1917	101,500
Otter Rapids	Abitibi	1961		174,800
Pine Portage	Nipigon	1950		128,700
Ragged Rapids	Muskoka	1938		7,700
Ranney Falls	Trent	1922		7,900
George W. Rayner	Mississagi	1950		42,300
Red Rock Falls	Mississagi	1960		40,500
Sandy Falls	Mattagami	1911	1944	3,500
Robert H. Saunders- St. Lawrence	St. Lawrence	1958		912,000
Seymour	Trent	1910	1916	3,200
Sidney	Trent	1911	1916	3,200
Sills Island	Trent	1900	1937	2,300
Silver Falls	Kaministiquia	1959		45,000
South Falls	S. Muskoka		1915	3,800
Stewartville	Madawaska	1948		153,000
Stinson	Wanapitei	1925	1930	4,000
Toronto Power	Niagara	1906	1922	39,600
Trethewey Falls	S. Muskoka	1929		1,600
Upper Notch	Montreal	1930	1944	9,600
Wawaitin	Mattagami	1912	1944	11,800
Whitedog Falls	Winnipeg	1958		64,800

## thermal-electric stations

fossil-fuelled	location	placed in service	installed capacity kilowatts
Richard L. Hearn	Toronto	1951	1,200,000
J. Clark Keith	Windsor	1951	264,000
Lakeview	Mississauga	1961	2,400,000
Thunder Bay	Thunder Bay	1962	100,000
Lambton	Near Sarnia	1969	1,000,000*

### nuclear

Nuclear Power Demonstration	Rolphton	1962	20,000
Douglas Point Nuclear	Lake Huron	1967	200,000
Combustion-Turbine Units		1965	319,000

## current construction program

### hydro-electric stations

		scheduled completion date	capacity when completed
Wells	Mississagi River	1970	203,300
Lower Notch	Montreal River	1971	228,000

## thermal-electric stations

### fossil-fuelled

Lambton	Near Sarnia	1970	2,000,000
Nanticoke	Near Port Dover	1977	4,000,000
Lennox	Near Kingston	1977	2,295,000

### nuclear

Pickering	Pickering Tp.	1973	2,160,000
Bruce	Near Kincardine	1978	3,200,000

\* Two generating units operating by end of 1969; two more units installed in 1970.

## hydro at a glance

plants in operation	68 hydro-electric stations
	5 coal-fired stations
	2 nuclear power stations
plants under construction or approved for construction	2 hydro-electric stations
	3 fossil-fuelled stations
	2 nuclear power stations
power lines	20,000 miles of transmission line
	51,000 miles of rural distribution line
power consumers	1,750,000 served by more than 350 municipal utilities who purchase power from Ontario Hydro
	28,000 served by 14 municipal systems owned and operated by Ontario Hydro
	98 direct industrial customers and interconnected systems
	577,000 rural customers served directly

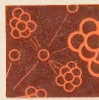
For information about films, talks, guided tours of major power developments and a variety of pamphlets, write to Public Relations Division, Ontario Hydro, 620 University Avenue, Toronto 101



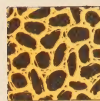
# ontario hydro



water



nuclear fission



fossil-fuel

